Advanced Gamma-Ray Telescope

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This year, MSFC Space Sciences Laboratory scientists have become part of a new effort to establish a future mission for studies in gamma-ray astronomy in the timeframe following the Compton Gamma-Ray Observatory (GRO). The generic term for the new mission is the gamma-ray large area space telescope (GLAST) and the MSFC contribution to the effort is the development of a scintillation fiber telescope for energetic radiation (SIFTER). This research and technology development activity is being conducted in collaboration with investigators at the University of Alabama in Huntsville and Washington University in St. Louis.

In the energy regime above 20 MeV, the most energetic processes and most luminous objects in the universe are studied. The observational difficulties of this region have resulted in a relatively slow start in this new branch of astronomy, but the successes of the Compton GRO have pointed the way to new discoveries and avenues of research for the future. Among the many discoveries and studies made in this high-energy region have been active galactic nuclei (AGN's), a new type of high-energy object called blazars, diffuse gamma radiation from cosmic-ray/molecular cloud interactions, high-energy gamma rays (prompt and delayed) from gamma-ray bursts, several new gamma-ray pulsars and as-yet unidentified sources.

A review panel chartered by NASA Headquarters' Office of Space Science has indicated that a major new thrust in high-energy gamma-ray astronomy (>30 MeV) with at least 10 times the sensitivity of previous missions should be pursued. This new mission would build on the discoveries of the Energetic Gamma-Ray Experiment Telescope (EGRET) on the Compton GRO and extend the field into new domains of temporal variability and spectral measurements. As shown numerous times in modern astronomy, new classes of sources and phenomena may be expected with an order-of-magnitude increase in sensitivity.

The detector system under study uses the same basic principle (tracking of the initial electron-positron pair and its subsequent development, scattering, and absorption) as that used in all detector systems in high-energy gamma-ray astronomy above ~20 MeV. Many variations of the tracking elements have been developed or proposed. These include spark chambers, drift chambers, gas microstrip detectors and solid-state strip detectors. We propose to utilize a different technology: scintillating fiber optics.

For most other proposed detector systems for high-energy gamma-ray astronomy, such as silicon solid-state strip detectors, the major cost of the system is in the active detector elements. Thus, their cost scales directly as the sensitive area. A 1-m^2 system is usually specified in order to stay within a reasonable cost constraint. By contrast, in the scintillating fiber optic system proposed to be developed here, the active detecting elements (plastic scintillating fibers) are a small fraction of the total detector cost. The major cost is the optical read-out system, around the perimeter of the active area. Thus, the cost scales as the square-root of the active area and total active areas of several square meters should be well within the cost constraints of a medium-sized Explorer mission. Furthermore, continuing developments in the high-energy physics community as well as new optical technologies can be utilized for the system proposed here for both increased performance and reduced costs.

Recent advances in optical fibers, image intensifiers and solid-state optical readout systems have now made this technology feasible as the basis of a low-cost, large-area detector system for high-energy gamma-ray astronomy. The scintillating fiber technique is already well-demonstrated and is successfully used in many applications for high-energy physics and cosmic ray research. Calculations and simulations have been performed to indicate reliable and accurate gamma-ray identification and characterization using a multilayered scintillation fiber and lead sheet array. Simulated gamma-ray tracks in a SIFTER are shown in figure 163. From these tracks, both the direction and the energy of the incoming gamma ray can be determined. The first 2 years of this development will be devoted to continuing computer simulations with various array configurations and determining the performance of such arrays directly by gamma-ray beam tests at a particle accelerator.

Sponsor: Office of Space Science

University/Industry Involvement: University of Alabama in Huntsville; Washington University (St. Louis)

Biographical Sketch: Gerald J. Fishman is an astrophysicist in the Space Sciences Laboratory at MSFC and is the head of the gamma-ray astronomy research group there. His primary research has been in the fields of gamma-ray astronomy, nuclear astrophysics and background radiation in space. Presently, he is the principal investigator of the Burst and Transient Source Experiment (BATSE) on the Compton GRO. He obtained his Ph.D. in 1969 from Rice University.

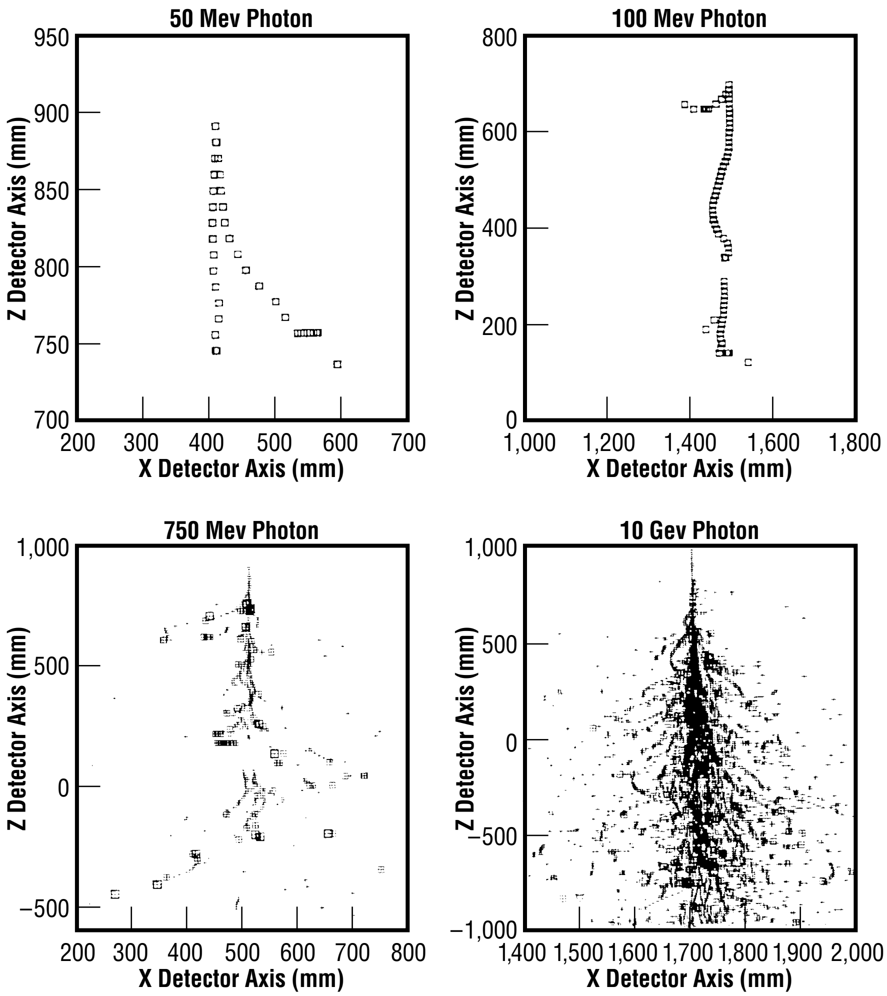

FIGURE 163.—Computer simulations (x-y views) of gamma-ray-produced tracks through an array of plastic scintillator fibers and lead sheet stack at two different energies.